Muon Tracking for Background Rejection in KamLAND

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Spallation products from cosmic ray muons are the single largest source of background events in the KamLAND reactor anti-neutrino experiment. At an average energy of approximately 200 to 300 GeV at the KamLAND site, these muons produce neutrons and short-lived isotopes such as ^{9}Li, ^{11}Li and ^{8}He which may be confused with the delayed-coincidence signal of reactor $\overline{\nu}_e$. With isotope half-lives in the range of 0.09 s to 0.18 s and a muon rate in KamLAND of about one muon event every three seconds, vetoing the entire detector after each muon would have a significant impact on detector live-time. Given that these cosmogenic backgrounds occur near the muon track, by accurately locating the muons passing through the detector one can use position information to reject these backgrounds with a minimal loss of detector live-time.

A muon fitter has been designed and is currently being tested on KamLAND data. The fitter uses time and charge information from the inner detector photomultiplier tubes to reconstruct the muon event. It relies on a model of light propagation which assumes detector light saturation during these extremely high energy events. (As a note, the inner detector was designed to detect neutrino events with energies near 1 MeV, while a single muon event deposits near 1 GeV. It is only by virtue of the dynamic range of the LBNL-designed electronics that events with this broad range in energy can be captured and understood.)

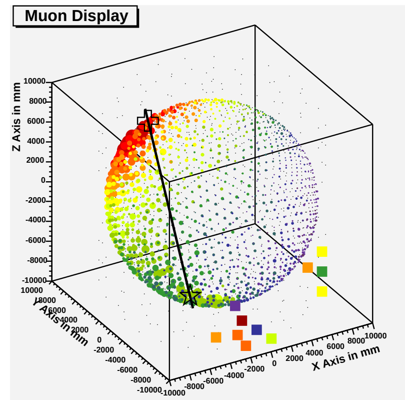

FIG. 1: A typical muon track. Circles represent inner detector PMTs, squares are the outer detector. The size of the circles are proportional to the charge seen by the PMT, while the squares are not scaled. The color represents time: beginning at red and progressing to blue. The cross is the reconstructed track entrance, while the star is the exit.

Currently, the muon fitter is able to fit tracks to 93% of the high energy events that occur in KamLAND. For these reconstructed tracks, a relation between the track length in the detector and the total event energy was found to be in agreement with expectations. An example of a through-going muon event and the reconstructed track can be seen in Fig. 1.